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# Technology: Servant or Master? An Economic Viewpoint[1]

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**Abstract**: Notwithstanding the notion of progress, the social and environmental record of our age poses serious doubts for the present and the future. Technology, being the mainspring of progress, may be seen, accordingly, as the master of history more than the servant of society. In line with this view, a case can be made to strengthen the value of technology and to weaken the deterministic character of history. To do so, the paper canvasses the use of artificial markets designed to improve compliance of technology with environmental or social standards. The emerging interest in following this path poses a radical departure from the traditional policy approach to technology assessment. The traditional approach may be described as *ex ante*, relying on cost–benefit analysis to anticipate the welfare effects of technology, combining this analysis with bureaucratic management based on command and control. Cost–benefit analysis, however, is piecemeal and shortsighted and, in a dynamic and synergistic world, can be considered of limited value to ensure longer-term goals. On the other hand, artificial markets operate *ex post* and on the basis of ambient standards. As such, they constitute an artificial device that does not require discretion and a predictive capacity that social science cannot offer. Nonetheless, and given political will, this new approach offers the potential to ensure efficient and sustainable outcomes under conditions of uncertainty.

**Keywords:** Artificial markets; Augmented capitalism; Environment; Technology

## 1. Introduction

The very technology that sets humans apart as smarter than other earthly life forms can be envisaged also to turn against society by repercussions that lie beyond the intention and control of inventor or innovator. Critical implications for the transformation of society due to technological revolutions will not necessarily be foreseen or be foreseeable, yet they may have the capacity to balance out in a negative or even catastrophic way. This is not to deny the 'idea of progress' in a century marked by

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spectacular technological advance[2] (see Bury, 1955, or Bronowski, 1973). During this century, after all, technological advance has been the cornerstone of the rapid economic progress that has brought an unimagined standard of health and welfare to countless millions. Nonetheless, there plainly are sides to technological change that give rise to concern and alarm. These downsides will be emphasised in this paper, although the emphasis is not intended to detract from the positives flowing from technological change. Rather, it is to see the positives strengthened by assisting to avoid or minimise the use and development of technology that does not serve the interest of society.

The downsides of technological change are of course well known. Implicated are military technology that permits gross destruction, or modern surveillance technology, the abuse of which has the potential to corrupt societal welfare. However, concerns in these regards are not the subject of this paper. Instead, the paper is concerned with technologies – embodied in products, processes and organisational forms – that are being accepted by societies as the legitimate mark of economic progress. For instance, private motor cars are such a product. The ubiquitous car carries an impact on the landscape, the urban environment and on the modern way of life that is safely described as momentous. As part of this impact, the motor car delivers a gigantic positive transport contribution – a contribution daily endorsed by the choices of armies of motorists. On the other hand, private motoring raises serious social and environmental considerations that present the downside to automotive progress. Indeed, the overall economic viability of this technology can be brought into question on account of its downsides.[3] The question is pertinent, as is the fact that the repercussions of the petrol-driven combustion engine would hardly have been imagined by its inventor, Otto, or by his contemporaries, a mere hundred years ago.

A second, equally familiar example relates to the development of nuclear energy generation. Again, the downside of this technology potentially negates the positive contribution, especially if the technology's future risks are not understated – as they have been – by a high discount rate. What is critical in these and other examples is not that the downside of selected technologies outweighs the upside. Rather, the critical point is that the downside of a technology is not assessed by social and environmental criteria in the same rigorous way that commercial criteria are applied.[4]

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[2]This paper has benefited from helpful comments made by John Fisher, Department of Economics, University of Newcastle.

[3]One way of questioning the efficiency of the private motor car is to calculate what might be termed the *economic speed* of motor cars. It may be found that the economic speed of cars need hardly exceed the speed of walking while being almost certainly slower on average than public transport or the humble bicycle. Economic speed is simply kilometres driven over the time required. Yet, this concept differs from *technical speed* because it counts not merely the driving time but also the time equivalent of both the private and social costs of motor cars. A calculation along these lines has been proposed by Illich (1973) and, before him, by Thoreau (1854/1986).

[4]Technology, of course, is tested before all else on scientific and engineering grounds. A device or a process or an organisation has to work and work reliably. Then the commercial test follows to see whether the costs of production can be recovered with an adequate measure of profit. Social and environmental tests are also applied. Is the device or process sufficiently safe from the point of view of humans? Is there a problem of pollution, of resource waste or loss of conservation value? Is conflict minimised and are statutory rights respected by organisational practice? It seems in these matters that the commercial test is generally strong, military and associated technologies being an exception. On the other hand, social and environmental tests appear weak on the whole. For instance, a new technology which will bring about the demise of an existing industry need not contribute to the remediation of human and capital obsolescence so caused. Likewise, technology has currently no responsibility in respect of environmental sustainability. Only existing environmental statutes must be complied with.

By and large, the social and environmental consequences of new technologies are difficult to predict at the time of the design and adoption of these technologies. Subsequently, as the social and environmental consequences unfold, only a weak institutional framework is in place to provide checks and balances. Since the early days of industrialisation, therefore, technical revolutions, now experienced at an accelerated pace, have been accepted as an article of faith. The faith is that the commercial profitability of a new technology justifies the social and environmental adjustments thereby necessitated. Faith in this respect is strengthened, since the social and environmental impacts of a new technology can be extremely difficult to predict in respect of sign, magnitude and character.

The complaint that the merits and demerits of new technology are not, or cannot, be fully accounted for, is illustrated in Fig. 1. Figure 1 suggests that commercial outcomes, relative to social and environmental outcomes, have a strong bearing on the choice of technology and, even more significantly, on its future direction. The suggestion essentially derives from the decision-making principle of profit maximisation that provides the arbitrating norm of what technologies will be implemented or abandoned. Granted a system of guidance by profit maximisation and granted that profit represents the return to the production factor of capital and capital alone, social and environmental considerations are found to be accordingly suppressed. Wages and salaries, for instance, are interpreted as a cost in the profit equation. As a cost, they are to be minimised by labour-saving technology even when long-term problems of unemployment arise as a result. Likewise, the environmental detraction occasioned by the pursuit of commercial activities has frequently been excluded from the profit calculation. Hence, the impressive record of technological progress shows this progress to derive mainly from revenue enhancement and cost saving while being modest in terms of environment-saving technology.[5] In order to change this apparent tendency for technological bias, the paper advocates that, where appropriate, social and environmental costs be internalised,

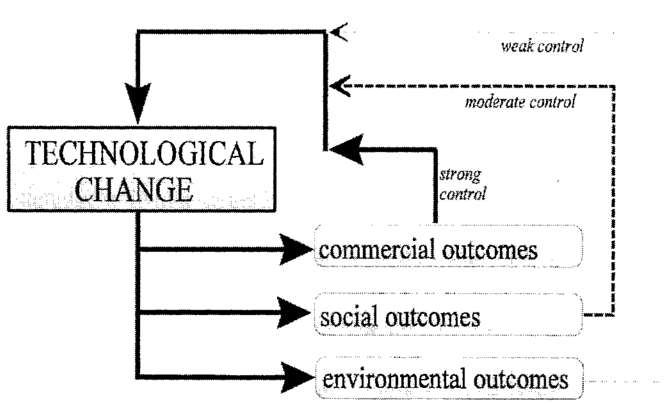


**Fig. 1.** Technology: Servant of commerce but master – in varying degree – over social and environmental outcomes.

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[5]Environment-saving technology in this regard must not be confused with environment-replacing technology (see Doeleman, 1992).

i.e. become part of the profit-based decision-making mode. The 'polluter pays principle' , widely accepted but sparsely implemented, provides a lead in this direction (OECD, 1989, 1996). It is this lead that will be pursued in some detail.

The paper is organised in two sections, each divided into three parts, followed by a conclusion. The first of these, section 2, seeks to bolster the case in favour of government intervention aimed at improvement of the social and environmental outcomes that flow from the technologies embodied in a modern economy. The second section, section 3, will argue how intervention might be organised in a market economy through extension of that economy with so-called artificial markets. This section will also consider the role of the traditional command and control approach to policy. Further, a brief account will be given of commonly encountered political objections to the views presented.

## 2. Policy and Technology

The case for policy to strengthen technological change in respect of social and environmental outcomes is not without controversy. First, a theoretical argument can be built to oppose government intervention in principle. In spite of the radical nature of this position, support is found amongst free-market ideologues as well as in some business quarters. Second and less extreme, government intervention is held to run counter to the alleged individualistic foundation of the market economy.[6] Thus the onus of proof, as it were, is on the interventionist according to this view. But proof might be difficult and, even if the benefits of intervention can be demonstrated to outweigh the costs, the issue is not sealed. The reason lies in the potential for government failure in the design and execution of its policies. An expectation of government failure may lead the shortcomings of market failure to be preferred.[7] Third, controversy also affects the fundamental choice between a policy approach based on penalties and one based on rewards. This last issue will be analysed at some length in what follows.

### 2.1 The Best of All Possible Worlds

The hardline anti-intervention position has deep roots in economics, going back to the notion of Pareto optimality. Anti-intervention is captured by the famous optimistic pronouncement of Dr Pangloss – Voltaire's character – exclaiming that 'we live in the best of all possible worlds'.[8] Rationality would dictate that if, in essence, the status quo were not the best of all possible worlds, then a move to the best of all possible worlds will make one or more parties better off without the necessity of

[6]In line with the work of Galbraith and others, the word 'alleged' is used because the dominant private actors in the market economy are large or very large organisations, some with budgets in excess of those of governments.

[7]In the extreme, government failure may take on malevolent proportions as portrayed by writers like Orwell, Kafka or Havel.

[8]See Voltaire (1759/1966) and the posthumous interview of Dr Pangloss by the Swedish Broadcasting Commission as faithfully recorded by E.J. Mishan (1973).

making other parties worse off. Society, in other words, automatically gravitates towards optimal arrangements. This would happen on the strength of a natural consensus that a proverbial small cake must be replaced by any available bigger cake, since the latter holds out more promise for all. Whether all will actually receive more is sometimes deemed not to be a matter of efficiency but of equity and, therefore, the supposed concern of politicians rather than economists. Leaving aside (until the next subsection) how the welfare of the best of all possible worlds is distributed, it seems that the only obstacle to achieving a Panglossian state of affairs is made up of transaction costs involved in moving there. Given knowledge and purpose, it thus follows that intervention is not required. That is to say, not unless transaction costs are thereby reduced.

The above position was fortified by Nobel laureate R. Coase in his influential article *The Problem of Social Cost* (1960). With the aid of numerous examples, Coase demonstrates that social costs – today usually referred to as external costs – do not necessarily require intervention as had been held before him by Pigou (1932). Whether the law protects the victim of external costs or whether no protection is put in place, rational decision making, according to Coase, will tend to produce a similar optimal outcome in respect of external costs. Regarding his ambivalence over the need for legislative or other government action Coase writes:

> The belief that it is desirable that business which causes harmful effects should be forced to compensate those who suffer damage ... is undoubtedly the result of not comparing the total product obtainable with alternative social arrangements. (Coase, 1960: 40)

He specifically takes Pigou to task for arguing that social costs *do* establish a case for intervention. Pigou wished to deal with air pollution by the imposition of a tax on smoke. According to Coase:

> Without the tax, there may be too much smoke and too few people in the vicinity of the factory; but with the tax there may be too little smoke and too many people in the vicinity of the factory. There is no reason to suppose that one of these results is necessarily preferable. (Coase, 1960: 42)

The Coasian non-intervention position can be developed textbook fashion with the aid of Fig. 2. In Fig. 2, the marginal internal benefit schedule (MIB) and the marginal external cost schedule (MEC) intersect at *A*. The MIB schedule represents the marginal private net benefit from a commercial activity measured against the level of activity.

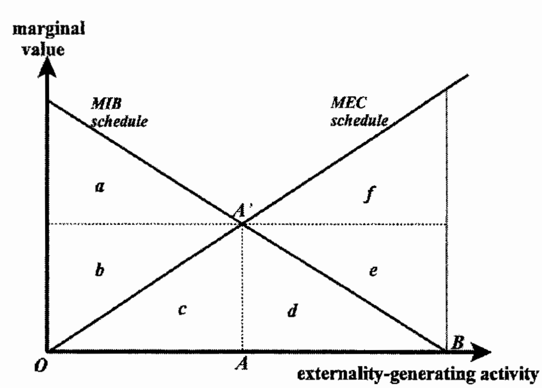


**Fig. 2.** Achieving optimal activity (=OA) without intervention.

Typically, this schedule gives a company's profit for subsequent units of production. As is usual, the marginal (extra) profit of an extra unit of production is assumed to decline, be it not necessarily in the linear fashion shown. The decline reflects that increasing supply will adversely affect revenue and, at some stage, also costs. Along similar lines, the MEC schedule represents the additional external costs of social or environmental spillovers (e.g. pollution) associated with increasing the level of commercial activity for a given state of technology. The schedule rises because, although the physical negative influence would generally be proportional to the production level, the impact in terms of damage is likely to compound. Again, the rise need not be of the linear format shown.

Taking the producer's private or commercial point of view, production will be expanded to level $OB$. At $B$ production is no longer profitable and profit will then be maximised at the level represented by areas $(a + b + c + d)$. In the light of the external costs, however, it is easily ascertained that production level $OB$ is socially inefficient. While the company counts its private profit as the areas $(a + b + c + d)$, the community (including the company) gains areas $(a + b + c + d)$ minus the total of external damage shown as areas $(c + d + e + f)$. The social value of the production therefore is much less than the private value. Indeed, social value could prove negative. So the question arises: what is the socially optimal level of the externality-generating activity?

The answer is to reduce production while the marginal external cost (the spillover cost of the 'last' unit of activity) exceeds the marginal internal benefit. Starting from point $B$, external costs exceed commercial profits up to point $A$. Accordingly, point $A$ defines the optimal level of output and of external cost, the level for which social welfare is maximised. Point $A$ will also be arrived at when starting from point $O$. In this case, production may be expanded but only while marginal commercial profit exceeds marginal environmental cost. Maximum social profit as attained at activity level $OA$ is represented by the difference between profit $(a + b + c)$ minus external costs $(c)$, equalling areas $(a + b)$.

### *2.1.1 Non-Intervention*

Coase writes that a so-called free or non-intervention regime can lead to the optimal outcome $OA$ even though the prima facie outcome under profit maximisation has been identified as $OB$. An allocation of activity at $OB$, he argues, might be expected to mobilise the externality-affected party. For instance, the community of a neighbourhood is envisaged to mobilise as a result of the adverse effects of local industrial pollution. Under those circumstances, Fig. 2 serves to point out the intervention-free way to the best of all possible worlds, reached after a cutback of activity to $OA$. The cutback can be achieved through the offering of bribes by the community to the producer at the mutually advantageous terms of $AA''$ (the bribe per cut unit of production). Both parties can be seen to win relative to their position in $OB$. The producer gains $(d + e)$ in bribes for a sacrifice of $(d)$ in profit, while the community gains $(d + e + f)$ in suffering now avoided in exchange for the lesser payment of $(d + e)$.

The significance of the above finding is that, at least in theory, optimal allocation can be attained without government interference. In other words, market efficiency need not be impaired by social or environmental spillovers of economic production

and its underlying technology. In practice, though, bribe terms may not conform with the optimal level *AA'*. Terms in excess of *AA'* would be indicative of uneven bargaining strength favouring the polluter, while terms below *AA'* suggest bargaining unevenness favouring the polluted party. In these cases, suboptimal production and pollution outcomes are held to result. Furthermore, transaction costs might rule out trade altogether, suggesting that OB is the best attainable outcome. However, as we will see, bribes may not be paid for another reason that, tellingly, Coase has omitted to mention.

### *2.1.2 Intervention*

Whereas non-intervention sanctions the freedom to pollute or to cause other adverse external spillovers, the intervention regime negates this freedom. Production or products deriving from technology associated with negative externalities will now be regulated. Regulation need not normally take the form of prohibition. Rather, the form may be to suspend control when terms of compensation can be agreed upon, thus satisfying the Pareto test that no one is worse off. Negotiations over compensation might be conducted by the affected parties in a private capacity or be undertaken collectively. Private negotiations require a bill of environmental rights to supplement the existing legal framework based on private property and personal freedom. For pollution and other forms of environmental and social detraction, however, a collective approach would appear more efficient.[9] A collective approach is expected to exact compensation in the form of either the very taxes challenged by Coase, or by means of the government rationing or selling permits (licences) to those who wish to generate external costs.

Negotiation over private or community terms of compensation holds the same potential of leading to the socially optimal level of production and pollution as seen for non-intervention. Continuing with the example of a polluting industrial activity, the analysis of Fig. 2 proceeds in this case from starting point *O* where production is zero. The absence of production establishes a socially inefficient outcome since profits in excess of environmental costs are forgone. To exploit the stifled opportunity, the producer/polluter must find compensation terms acceptable to individuals or to the community adversely affected. In the ideal solution, compensation terms are found and settled at *AA'* per unit production. At these terms, the producer is permitted to expand production to the level *OA*, the point at which the rate of compensation no longer exceeds marginal profit or the external costs as measured by the MEC schedule.

Under an intervention regime, economic arbitration need not produce compensation terms of *AA'*. As in the non-intervention case, disproportionate bargaining strength may distort the terms of compensation, thus leading to an outcome of production and pollution that is either too high or too low. Likewise, no terms may be found at all, thus preventing any production from taking place and raising the question of the relative social loss of no production compared to the social loss of the unrestrained

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[9]The remedy emphasising individual property and amenity rights is handicapped by the definition of environmental or social titles that are essentially indivisible as well as by the multiplication of private transaction costs. This handicap often constitutes the precise reason why social and environmental values may have remained external to private decision making.

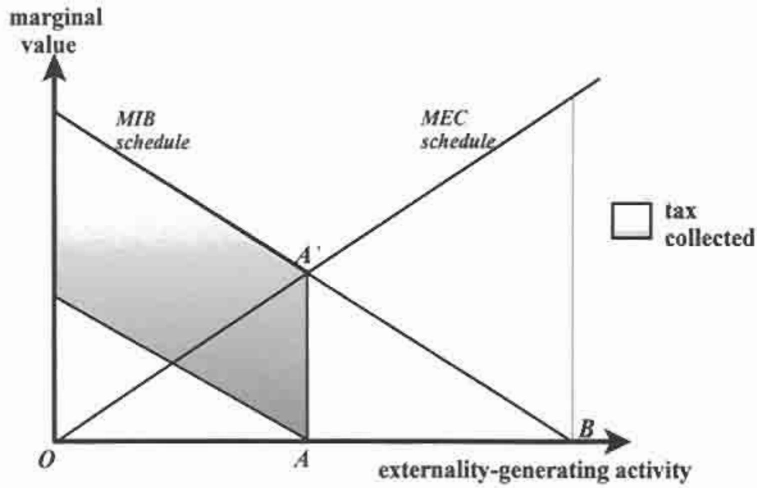


**Fig. 3.** Pigovian taxation of negative externalities.

level of production at *OB*. If no terms of compensation are found, the indication is again that transaction costs are so high that no social profit may be available. In a number of instances, however, high transaction costs may be mitigated by a collective approach.

The pollution example provides an illustration of the merit of a collective approach. Generally, it would be more practical for an industry to offer compensation to a polluted community by means of the payment of taxes or charges than it would be to pay each individual adversely affected by pollution a personal compensation package. This is illustrated in Fig. 3, where a tax of *AA'* is levied on each unit of production. As can be seen in the diagram, this tax level will result in the optimal allocation of the externality-generating activity as shown by *OA*. How the desired tax level is established will be discussed in section 3.1.

Whilst neither a non-intervention nor an intervention regime need necessarily realise the correct terms of *AA'*, both regimes are envisaged as capable of delivering an optimal or near-optimal outcome. Coase therefore takes a position of allocational indifference between intervention and non-intervention.[10] To him the analysis suggests that both the non-intervention and the intervention approach are compatible with an optimal allocation of a socially or environmentally damaging activity. If this view were accepted, the choice of regime becomes one of expediency. In particular, the choice is governed by the regime expected to achieve an optimal allocation at a lower level of transaction costs. Transaction cost being equal, however, non-intervention is deemed preferable in line with a distrust of government and in line with an affinity for the Panglossian view of the world.

[10]The allocational symmetry of a non-intervention and an intervention state of law is not in fact in strict accordance with theory. Allocational results will vary between the two regimes given that the marginal utility of money falls when income rises. When the marginal utility of income falls, the *willingness-to-pay* bribes in money terms differs from the *willingness-to-receive* compensation in money terms even though the disutility of the environmental spillover remains the same. Accordingly, the marginal cost curve of Fig. 2 shifts to a lower curve in the non-intervention case and a higher one in the intervention case. In respect of the argument canvassed in the paper, this technical point is of little consequence.

## 2.2 Penalty, Reward and Government

Predictably, the idea of achieving the best of all possible worlds without the assistance of government has been the subject of extensive critique. The main points of this critique will be highlighted below. Perceptions of the weight of this critique wax and wane from time to time together with perceptions about the role of government in general. Currently, OECD countries appear to be in a waning phase in line with the ascendancy of 'economic rationalism' and in line with a weakening of the position of labour vis-à-vis capital.

In spite of a current downturn in enthusiasm for intervention, the role of government appears set on a growing trend, described by Hirsch as the path towards reluctant collectivism (see Hirsch, 1977). From the narrow beginnings of providing internal and external security in centuries past, the twentieth century state has assumed responsibility in health and education, social welfare, distributional policy, employment policy, monopoly control, and more. In the present context, the focus of a growing role for the state is on the management of social and environmental external cost arising from the modern reliance on technology. It is in this context that the critique on the non-intervention position should be read. The critique can be organised under the headings of: free riders, future generations, distribution and incentives. Of these, the combined heading of distribution and incentives is central to the analysis canvassed in the paper.

The free rider argument defines the difficulty of collective action, especially when the external cost is suffered by many and in a diffuse manner (see Olson, 1971,1982). This difficulty awaits those wishing to organise themselves to pay off external costs as foreseen by the non-interventionist argument. However, in part, the difficulty can be alleviated by the use of existing government channels, thus defeating the idea of non-intervention. Similarly, the idea of self-negotiation and non-intervention is defeated when external costs affect parties not yet born. A specific example is found in the intergenerational risks of nuclear technology. More generally, it could be claimed that technology-enabled economic development is detracting systematically from conservation values belonging to future generations.

A further criticism on the non-intervention position relates to distribution. The notion of distribution is closely connected with incentives. According to Coase, the optimal outcome *OA* of Fig. 2 can be achieved both with and without intervention. Optimality, however, strictly relates to efficiency. The equity of the optimal outcome is very different under the intervention regime compared to the non-intervention regime. Table 1 sets out the difference. It uses the areas outlined in Fig. 2 as they apply to the case of a polluting production process and shows that intervention yields gains for

**Table. 1.** Intervention and distribution.

| **NET DISTRIBUTION According to Figure 2** | **producer/polluter party** | **polluted party** |
|---|---|---|
| **intervention regime** | *a= profit (a+b+c) - compensation (b+c)* | *b= compensation (b+c) - pollution (c)* |
| **non-intervention regime** | *a+b+c+d+e = profit (a+b+c) + bribes (d+e)* | *-c-d-e = -pollution (c) - bribes (d+e)* |

both polluting and polluted parties while non-intervention results in gains only for the polluter, leaving the polluted party environmentally and financially worse off.

The distributional asymmetry tabulated in Table 1 is not merely of concern in terms of equity. It seems highly relevant in terms of efficiency, regardless of Coase's finding to the contrary. The problem is that the analysis of Fig. 2 fails to reach beyond its comparative static framework. It misses thereby the dynamic feedback of incentives that stem from the distributional outcome.[11] In a dynamic view, the gains (rewards) and losses (penalties) that arise under intervention and under non-intervention can be seen to act as incentives and disincentives carrying repercussions of crucial importance for the shape of technology in the long run. Accordingly, the intervention regime brings with it an incentive for the generator of external costs to apply and to develop externality abatement techniques. By means of abatement, compensation payments can be reduced or externality-based taxes avoided. On the other hand, in the non-intervention case the same incentive to develop and apply externality-preventive measures does not hold. In fact, profit-seeking behaviour on the part of the externality-generating party indicates the contrary. In theory, more profit (through extra bribes) could be gained by the pollution becoming worse![12] The perversity of this finding is highly significant. Moreover, it provides good reason why, in the real world, the bribe solution is likely to be avoided. Paying bribes is not rational in dynamic terms because of the dangers of thereby sanctioning a potentially exploitative or extortionist situation. For this dynamic reason, a polluted party may

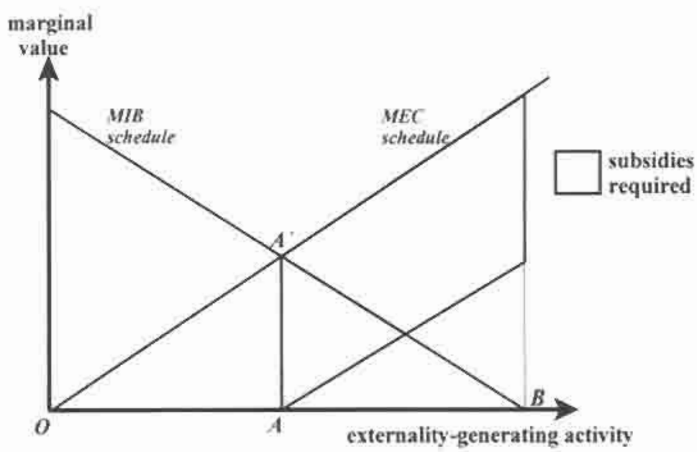


**Fig. 4.** Achieving optimal activity (=OA) by means of subsides.

[11]Economists, in their desire to be 'objective', have a propensity to concentrate on allocation as if efficiency questions can be separated from equity considerations. The same propensity also afflicts cost–benefit analysis.

[12]An antisocial scenario in which polluters seek to become worse polluters in order to extract more bribes is one of holding the community to ransom with the threat of environmental contamination. This interpretation does not describe the reality of normal commercial enterprise where environmental costs arise as unwanted by-products of otherwise productive economic activities. Instead, it describes enterprise of a criminal or military class. Nonetheless, even though economic agents need not act on the perversity of incentives under non-intervention by building up a capacity to impose costs on others, the incentives to diminish external costs are not as they should be.

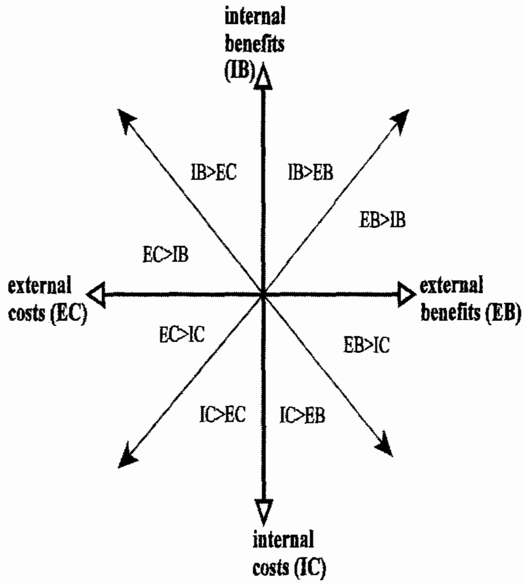


**Fig. 5.** Externalities generalised.

rationally decide to resist paying off the polluter even though, according to Fig. 2, suffering is not minimised in the (comparatively static) short run.

Having thus made the case in favour of intervention on dynamic grounds, a warning must be sounded that it is possible to envisage the wrong type of intervention. The wrong type of intervention has the potential of carrying the same counterproductive incentive structure of non-intervention while also failing the freedom of non-intervention. The wrong type of intervention is based on subsidies. If non-intervention does not produce a move from *OB* in Fig. 2 to the optimal allocation level *OA*, then it is possible to achieve the optimal outcome by means of government subsidies. The subsidy solution is presented in Fig. 4. The community pays the generator of external costs a collective bribe for every unit of production forgone, starting from *OB*. Given subsidy terms are *AA'*, the optimal allocation of *OA* will again be achieved. In dynamic terms, however, the distributional outcome is not equitable and the incentive structure to select and develop beneficial technology is counterproductive.

## 2.3 Internalisation of Externalities

The internalisation of externalities can be treated in a generalised way to show that the case for government intervention need not apply uniformly. Closer examination shows a range of distinctly different externality situations as set out in Fig. 5. Figure 5 shows the internal benefits/costs (IB/IC) of an economic activity on the vertical axis and the external benefits/costs (EB/EC) on the horizontal axis. Assume party A to be the active decision-making party in respect of the internal consequences for A and party B the passive recipient of the external consequences. Party B holds no formal control over a decision by party A to change the status quo. Nonetheless, as will become clear, party B will not necessarily be without indirect decision-making

influence. The relationship between party A and party B depends on which of eight distinct net gain/loss combinations applies for the two parties and also on the extent to which each case applies. When moving in Fig. 5 from one case to the next, a gradual or amorphous change of the characteristics results. In describing these characteristics, parties A and B have been allotted a Hobbesian, self-seeking attitude towards the exploitation of any opportunities that may be present.

Defined in Fig. 5 as half-quadrants, each of the eight cases will be discussed briefly, moving counterclockwise and starting north-east to east.

- *Case 1: The external gain for B exceeds the internal gain for A (EB > IB).* The gain for B resulting from a change introduced by A allows for the outcome of A threatening B to withhold the gainful change. B, in response, might call A's bluff or opt to encourage A. Much may depend on the circumstances and on the actual size of each party's gain. Should B pay, it could be said that A has achieved internalisation. A priori and in the context of a market economy, it is not clear that A should be assisted by government intervention.
- *Case 2: The internal gain for A exceeds the external gain for B (IB > EB).* A's threat power is weakened compared to the first case. The change contemplated by A is likely to come about without negotiation and with B enjoying the windfall. Any case for intervention is weakened.
- *Case 3: The internal gain for A exceeds the external loss for B( IB > EC).* This case – and the next – represent the standard problem of external costs as portrayed in Fig. 2. Many economic activities, relying on accepted technologies, fit the pattern. B's option is to bribe A to moderate. As seen, however, this leads to an unsatisfactory distributional result as well as to the use of adverse technology. Intervention is recommended for these reasons and to restrain A from obtaining an exploitative advantage from the incidence of external costs.
- *Case 4: The external loss for B exceeds the internal gain for A (EC > IB).* The arguments of case 3 apply except that in this case intervention may take the form of outright prohibition because the community as a whole cannot gain.
- *Case 5: The external loss for B exceeds the internal loss for A (EC > IC).* Again, the collective interest cannot be served in this case. On the other hand, compared to case 4, there appears to be no need for intervention because the private interests of neither A nor B are served by change. The appearance is mistaken, however. Given that A's internal loss is small and B's external loss is large, A is capable of threat. While this threat may make no sense in the setting of economic enterprise, it may very well suit criminal purposes or military designs.
- *Case 6: The internal loss for A exceeds the external loss for B (IC > EC).* This case does not harbour any obvious problems. A holds no effective threat power over B. A, therefore, cannot exploit its power of control and the undesirable change need not normally be expected. No intervention appears to be required, an exception being found in spitefulness getting the better of 'rationality'.
- *Case 7: The internal loss for A exceeds the external gain for B (IC > EB).* As under case 6, no change is warranted from the collective point of view. Party B may be

interested in change, but cannot afford the inducement required to make A willing to enact the change. Similar to case 6, no intervention appears to be required.

- *Case 8: The external gain for B exceed the internal loss for A (EB > IC).* This is the final case, which can be recognised as the regular case of free market trade. This case requires entrepreneurial initiative on the part of B along lines envisaged as standard in a free enterprise system. B is at liberty to internalise the positive external effects of the change by offering A sufficient compensation to make the change. Both A and B would be better off. Again there appears no need to intervene other than, of course, by the provision of a legal framework designed to protect personal freedom and property.

# 3. Harnessing Technology

## 3.1 Artificial Markets

Artificial markets present a policy innovation pioneered in environmental economics. They are an economic device capable of achieving commercial as well as social or environmental objectives. As such they rely on the use of financial incentives instead of on the regulatory approach known as command and control. An early impetus to the design of artificial markets has been contributed by the 'polluter pays principle'. This principle has already been alluded to in the introduction and is commonly cited as PPP. PPP has gained support in many quarters, including the Brundtland Report, which traced back official endorsement to 1972, when OECD countries first decided to base their environmental policies on PPP (World Commission on Environment and Development, 1987: 221). Many years later, much remains to be done to put theory into practice. According to one critic concerned with air pollution – a prominent field for the application of artificial markets – policy approaches to date have tended to be 'technological band-aids' (French, 1990). Similar sentiments apply across the spectrum of environmental policy since the potential of economic instruments extends beyond pollution to problems of congestion, to problems of over-exploitation of land, water, mineral and biological resources, as well as to problems of the management of conservation questions. In fact, the scope for environmental charges appears wider than is generally acknowledged, making it preferable to abandon the phrase 'polluter pays, in favour of 'environmental detractor pays' or EDP (cf. Doeleman, 1997).

Having suggested a widening of PPP to the EDP principle, this paper proposes to go further. EDP remains limited to dealing with *environmental* external cost. However, the present concern is that technology also imposes *social* external costs. Central in terms of social spillovers is the propensity of technology to be labour-replacing. In addition, other social costs might be associated with the introduction of new technologies, as are, of course, a variety of social benefits (for example, see Toffler, 1973, 1981). In selected cases, in particular the case of unemployment, an artificial market device may hold out promise for the management of socially adverse consequences of technology.

Focusing on the propensity of technology for labour replacement, it is tempting to pronounce in this regard a 'social detractor pays' principle (SDP). However, care is needed to adhere to the correct choice between reward and penalty. This choice, it

has been shown, impinges on the dynamic incentives and is of key significance for the shape of current and future technology. The problem with condemning labour replacement is that labour replacement constitutes the very source of per capita economic growth and cannot therefore be considered a detraction. In order therefore to achieve a desired employment outcome, the incentive structure of an artificial market would need to be based on rewarding employers maintaining or expanding their workforce rather than penalising those who lay off staff.

To demonstrate how an artificial market might determine the appropriate level of penalty or reward, consider first the example of an industry relying on a polluting technology. In accordance with EDP, this is a case in which a penalty is applied so that the perverse technological incentives discussed in Section 2.2 are avoided. Suppose the penalty is applied conforming to Fig. 3, in which a tax of *AA'* leads to an optimal allocation in terms of production and pollution (*OA*). This tax, known as a Pigovian tax, also leads to an equitable distribution, one with technologically constructive incentives over time (after Pigou, 1932). Yet, the outcome would not be satisfactory. Notwithstanding the positive qualities of the tax, it poses two problems. The first is that the tax is levied on production (the economic activity) rather than on pollution (environmental detraction). It would be preferable to tax the pollution directly in order to deliver a more purposeful incentive to improve technology.[13] Second, while the determination of the correct level of tax at *AA'* seems straightforward in Fig. 3, it is most problematic in practice. In the real world, the positions of the schedules that define the correct level of tax are neither fixed nor known.

The trappings of a Pigovian tax are avoided by aiming the tax at environmental outcomes instead of economic ones. As can be seen in Fig. 6, the preferred variant of an EDP scheme may be organised around the realisation of an agreed environmental target value, following Baumol and Oates (1971, 1988; see also Tisdell, 1983). Agreement over quantitative settings of environmental targets is to be delivered by the political process which, in turn, might be guided by criteria that go beyond commercial considerations, including the notion of environmental sustainability, human health and safety, future generations, as well as non-anthropocentric values. Naturally, meeting such non-commercial criteria is a tall order given the pitfalls of the political process. However, a discussion of the failings and remedies of the political process falls beyond the scope of this paper. For the purpose of Fig. 6, therefore, it is simply assumed that the target level has already been determined on the basis of sound principle. This target is shown as a vertical line cutting the horizontal axis at *A*. The figure also shows the demand for environmental detraction for different levels of the tax. The demand schedule is represented by line *DCB*. In the absence of intervention, this schedule would indicate that taxes are nil, leading the demand for environmental detraction to reach level *OB*. Levels of

[13] It is not always functional to enforce environmental payments pro rata to each actual spillover. For example, motor vehicles generate many adverse spillovers. To tax these spillovers separately does not seem practical. In practice, a 'multi-purpose' tax on the proxy of fuel can be employed, thereby trading a loss of incentive for a gain in the efficiency of administration. Indeed, a number of countries claim that the taxation of vehicle fuel is justified in part on environmental grounds. While the effect of this tax is more fuel-efficient technology and a reduction in the reliance on the private motor car in favour of public transport, the tax will not in itself induce greater pollution efficiency (per litre of fuel). Nor will the tax encourage the reduction of noise, improve the recyclability of the motor car, or mitigate other drawbacks.

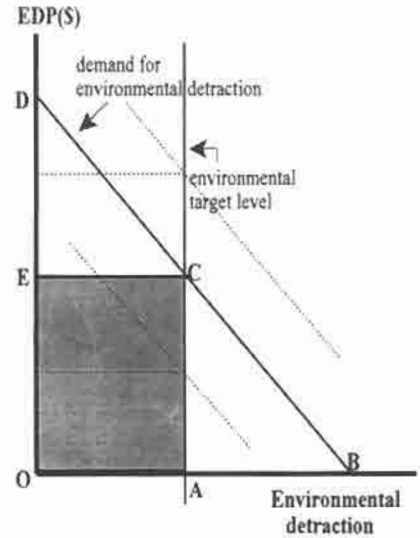


**Fig. 6.** EDP taxes and permits.

detraction lower than *OB* are attained for positive tax levels, the payments acting as an inhibitor. At tax payments of *OD*, demand for environmental detraction will be deterred altogether.

Figure 6 shows that the equilibrium tax rate is determined by *OE*. If the tax were lower than *OE*, environmental spillovers would be generated outside the target. On the other hand, a tax rate higher than *OE* is expected to produce results inside the target. The equilibrium tax rate is found by adjusting the tax upwards or downwards once the target is missed by a preset tolerance. Thus, the Pigovian difficulty of finding the correct rate has been overcome. The environmental tax is determined as in any market, by equilibrating supply (the target) and demand. The market of Fig. 6 only differs in having been instituted artificially on the basis of EDP intervention.

In common with ordinary prices, artificial market prices vary automatically when dynamic conditions change. Changing conditions will be reflected in a shift of the demand schedule (*DCB*) and define new solutions, as marked by the finely dotted lines. For instance, a downward shift in the demand for environmental detraction could be the result of environment-saving technical progress. Likewise, population growth would shift the demand schedule in an upward direction. Changing preferences could have an effect on demand in either direction or have a rotating impact. In this regard also, the Baumol tax is superior to the rigid Pigovian model.

To ensure that the environmental target is reached, a second device can be employed. This device is to auction permits with a total value equal to the target level *OA* (Dales, 1968, and Dales in Dorfman and Dorfman, 1993). The average permit price under this arrangement will be in equilibrium at level *OE*, when the price conforms with the intersection of demand and supply. In equilibrium, revenue is shown as quadrangle *OACE*. By contrast, no revenue is forthcoming if permits are *issued* (grandfathered) instead of *auctioned*. Under competitive conditions, however, the same price of *OE* might govern trade in issued permits. Trade is envisaged to

take place between detractors that find it relatively easy to cut back (permit sellers) and detractors that find it relatively difficult or expensive (permit buyers).[14, 15]

Figure 6 is readily adapted to the context of a social application. Consider, for instance, an artificial market designed to achieve a desired level of national employment. As indicated above, the incentive structure in this case relies on subsidising employment rather than on taxing the detraction from employment. To adapt Fig. 6, the vertical axis now measures subsidy levels that rise when moving up along the axis. The horizontal axis measures employment but showing falling levels when moving to the right and starting with over-employment at point $O$. In this framework, the vertical schedule represents the target level of employment while the sloping schedule of Fig. 6 shows different subsidy levels per worker with the associated levels of employment. The equilibrium level of subsidies is the level compatible with the target, marked as $OE$.[16] If employment were to fall below the target, subsidies would go up and, conversely, if the labour market exceeded its target, subsidies would be reduced. The level of subsidies is not predetermined thereby. However, it is not a bureaucratic hand that governs the adjustments of the artificial market under changing circumstances. Rather, it is the famous invisible hand championed by Adam Smith, albeit a hand that is artificially contrived in this case.

## 3.2 Command and Control

In strengthening the social and environmental performance of technology, artificial markets seek to extend the market system instead of replacing it as revolutionary reform has sought to do. By internalising social and environmental costs, the historically proven power of the profit motive can conceivably be harnessed to achieve technological progress that is not merely aimed at commercial success but also at social and environmental protection. In advocating extensive usage of artificial markets, the paper departs from the conventional command and control approach towards regulating the market system in respect of social and environmental considerations.

Artificial markets promise advantages over command and control. However, enumeration of these advantages must not be read to signify a proposal to abandon command and control. Instead, the argument favours a reduction in the reliance on command and control to the point only where the latter form of policy will continue to offer better outcomes. Where this point may be found will be addressed at the end of the current section. Presently, the advantages of the use of artificial markets over traditional regulatory instruments of social and environmental policy will be summarised. Artificial markets can be held:

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[14]In the United States, surplus pollution permits were first sold by Wisconsin Power and Light in 1992. The buyer was the Tennessee Valley Authority, who reportedly paid between US$ 2.5 and 4 million for the right to discharge 25,000 tons of sulfur dioxide.

[15]To date, the use of environmental permits has proved politically more acceptable than the use of environmental taxes. This could be explained because environmental permits have generally been of the issued variety, thus falling short of the principle that detractor pays. Environmental taxes, in this respect, offer better incentives for technological improvement. Also, they offer more flexibility and lower administration costs by allowing rapid adjustment when coupled to *real time* monitoring, computer pricing and automated billing.

[16]Target levels can be geographically differentiated. They may also be varied in other ways, e.g. by age group or by season.

- institutionally compatible with a market economy, thus allowing an evolutionary progression to change instead of abandonment of the existing system;
- target effective as a result of automatic penalty/reward adjustment;
- economically efficient in both the static and dynamic sense and in line with the need: (a) to economise on external costs; (b) to encourage substitution in demand through 'detractor pays'; (c) to substitute for less damaging technology; and (d) to direct the search for new technology to social and environmental ends as well as commercial ends;
- socially equitable since the party responsible for external technological costs is required to pay while the party responsible for external technological benefits may be rewarded.

These perceived advantages are amplified by what may be seen as disadvantages of the command and control approach:

- having to be even-handed, command and control requirements are generally inflexible, thus failing to take into account that the costs of abating any adverse external consequences of the use of a specific technology will differ from one regulated party to another;
- in addressing potential offenders, command and control requirements are piecemeal and, therefore, may prove inadequate in terms of overall social or environmental outcomes;
- command and control requirements do not readily adjust in the light of changing circumstances, establishing a danger of regulations that are out of date;
- a further danger is that of a 'cosy' and dysfunctional relationship developing between regulating and regulated party;
- although command and control regulation bears on prices, the price signals are expected to be muffled;
- considering the bureaucratic basis of the command and control approach, policy costs are potentially high;
- the bureaucracy as a supervising authority over business may lack in the necessary level of specific understanding to offer competence in regulation.

Having enlisted arguments that recommend the use of artificial markets, it is important to acknowledge that the scope for such markets is not universal. In other words, the command and control approach retains a role and one that appears to remain significant:

- in situations where the optimum level of external costs (at *OA* in Fig. 2) associated with the use of a technology is zero or near zero. These situations call for outright prohibition as artificial markets have no purpose. Examples of the need for outright prohibition abound. Usually they relate to health and safety concerns. They may also relate to the natural environment, e.g., the ban on CFCs or the prohibition of dynamite fishing;
- in the use of zoning (in space, in time, or against another criterion), constituting a common form of regulation in which an 'either–or' solution is preferred over the 'in-between' trade-off envisaged in an artificial market;

- for distributional reasons, because buying the right to generate external costs in an artificial market may be politically objectionable, as instanced by China's population policy;[17]
- on the grounds of the expense of implementing a market as, for instance, in the use of public roads. In this case, it can be seen also how technology may be changing the equation in favour of the use of economic instruments. The modern scope for electronic monitoring of road use coupled to computerised automatic payments points to a 'user pays' future for the open road.

### 3.3 Political Hurdles

Artificial markets are believed capable of improving the social and environmental performance of the technologies that underlie the processes of production and the output consumed by society. In many applications, however, the idea of artificial markets would involve taxes or charges on enterprise responsible for social or environmental detraction. Not surprisingly, therefore, a number of objections have been raised in political debate on this subject. The objection most often voiced is that competitiveness is at stake, especially in the international arena. This section will review this and two other commonly encountered objections to artificial markets. Furthermore, the section will conclude with a comment on a potential new impediment to the development of artificial markets. This impediment has arisen recently in the guise of the so-called Multilateral Agreement on Investment (MAI). Although the MAI in its current form has been shelved at the time of writing, the forces of globalisation are likely to keep this issue alive for some time to come.

Notwithstanding the need for international coordination, reluctance over the use of artificial markets on the ground of international competitiveness can be overstated. Much trade is of course domestic in nature. Second, cost factors between trading countries are far from equal in any case. Wages especially may differ by large margins. Indeed, cost differences are the very source of trade and national variations between social or environmental standards need not be an exception. Developing economies may choose to pursue lower social or environmental standards than more developed economies. Within the limits of human dignity and of environmental sustainability, this does not appear to present a cause for complaint. Third, higher social and environmental standards are already found in countries which are successful in international trade, including Japan and a number of Western European countries.[18] Further, with the need for more stringent environmental policy almost universally acknowledged, environment-protective economic activities are expected to enjoy a period of (rapid) expansion. Those countries that have been forward-looking in their environmental policy are also likely to take a major share of the trade that may be

[17]The market alternative to a command and control setting of the desired family size is found in the use of incentives or disincentives. For instance, taxes could be levied to ensure that average family size conforms to the desired target. Taxes, however, would fail the choice between incentives and disincentives. Subsidies for *not* having children may give a more sound footing to an artificial population market, as would Boulding's suggestion of issuing marketable baby licences.

[18]The United States, Canada and Australia have recently been characterised as cowboy economies in respect of the environment (Worldwatch Institute, 1996).

expected to derive from a comparative advantage built up through a lead in environment-protective know-how.

A second and related objection to the introduction of artificial markets is often put forward. Taxes or charges associated with artificial markets are claimed to add to the tax burden, which is likely to be considered too high in the first place. This form of opposition to the idea of artificial markets is fallacious, however. The fallacy arises because the extraction of social or environmental revenue is not seen against the background of a wider fiscal picture. In the wider picture, the overall tax burden has already been decided in the balance of political forces. The appraisal of artificial markets must not be mixed up with these forces, regardless of whether the tax level is high or low. Rather, judgment on the merits of artificial markets needs to be based on the presumption of commensurate relief of other taxes. This is also of great importance in respect of competitive concerns. Artificial markets must be viewed as tax neutral on balance. It means that an industry that finds its competitive position damaged by artificial markets on account of generating adverse social or environmental impacts will find the effect moderated by tax offsets now enabled. Better still, industries that are socially and environmentally clean may expect to pay *less* tax, thus finding their competitive position enhanced!

Allowing the taxation function of artificial markets to deliver commensurate cuts from other tax revenue sources, an additional point can be made. The point addresses the question of the relative merits of taxes gained and lost. Most taxes are considered a necessary evil in view of the distorting effect they have on market decisions. By contrast, artificial markets are proposed precisely for the positive value of the distortions they cause. It seems, therefore, that 'bad' taxes may so be replaced by 'good' taxes. Taxes on the use of labour, for instance, can be seen as unwelcome when employment is scarce.

A final objection to the use of artificial markets is found in unintended adverse distributional consequences. Industry in opposition to carbon taxes has argued this way, for instance. Again, separate purposes are disingenuously muddled together. In this case, the appraisal of an artificial market based on carbon taxes is asked to shoulder blame for adding to poverty by raising the price of car fuel and home heating. Poverty, however, needs to be addressed by systematic policies, including tax progression, social welfare measures, health and educational programmes, and so on. It is hard to see that controlling the price of fuel defines a systematic approach.

Having addressed some key objections to the use taxes and charges designed to achieve economic and technological change that will contribute to higher social or environmental standards, a final issue would appear to deserve brief attention. This issue concerns the recent OECD negotiations over the MAI. The MAI seeks to advance the free international movement of capital and is driven by the interests of corporate capital with an agenda to underscore the commercial outcomes of investment more than the social and environmental outcomes. Undue emphasis on the needs of capital reflects precisely the lament expressed at the outset of this paper in Fig. 1. Nevertheless, the MAI may give global investors the power to sue those nations that

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[19]The arduous progress on measures to combat global warming (cf. Rio de Janeiro undertakings of 1992 and Kyoto undertakings of 1997) provides a demonstration of the weakness of international decision making even when problems are truly global

place investor return at a comparative risk through national social or environmental policies. As a consequence, this agreement may point social and environmental policies to an internationally low, or lowest, common denominator. In recent years and in line with this development, the World Trade Organisation has already ruled in several cases that free international trade (like the free international movement of capital) constitutes a higher doctrine, one that takes precedence over national environmental concerns.

Admittedly, communities may be asked to think globally instead of nationally, in the same way as communities have been asked in the past to think nationally instead of provincially. The difficulty is that at the national level the interests of the community may be well served by effective and democratic national government. Internationally, however, the absence of strong governmental institutions is plain to see. Yet, the MAI forces social and environmental intervention to a global stage that remains largely void of supranational authority.[19] Hence, the erosive influence of globalisation on national jurisdictions poses a troubling development and one that is likely to sanction the capitalist bias of current advances in technology at the expense of social and environmental goals.

## 4. Conclusion

Spectacular technical progress has been achieved in the twentieth century and, as a result, the general populations of many countries now enjoy a standard of living without historical precedent. However, this century a high price has been paid in terms of losses sustained by the natural environment. In addition, affluence has failed to make satisfactory progress in improving the social environment. Poverty, unemployment, preventable illness, alienation, unequal opportunities in education and economic life, discrimination, all remain features of societies that appear to have the technological wherewithal and the prosperity to reach for better results. Better results, the paper suggests, may flow from rectification of a mode of economic decision making that is dominated by commercial considerations.

Rectification of commercial decision making can, in what may prove a substantial number of instances, be delivered by artificial markets designed to better exploit existing technologies for their social and environmental value and, importantly, to give social and environmental direction to the development of new technologies. In doing so, artificial markets do not prescribe the future. Nor do they challenge the existing economic order. Rather, artificial markets extend this order into a new form, which, for lack of terminology, might be described as *augmented capitalism*. In augmented capitalism, economic instruments of social and environmental policy are envisaged to provide correction of price signals currently distorted by the prevalence of external costs.

A secondary conclusion may also be drawn from the paper. This conclusion concerns the requirement that intervention is based on the appropriate set of dynamic incentives. Dynamic incentives have been found to play a vital role in respect of the development of technology and the wrong incentive structure could prove damaging. In this respect, subsidies to encourage environment-friendly behaviour have been identified as

counterproductive. For the same reason, taxes have not been recommended to encourage full employment. It seems there is a *rule of incentives* that stipulates to use taxes or penalties in the case of negative actions and rewards or subsidies in the case of positive actions. In accordance with this rule, pollution of carbon dioxide resulting from fossil fuel burning may be taxed while, concurrently, the sequestration of carbon dioxide in forestation can be subsidised.

The rule of incentives is familiar enough from personal experience. Parents would stand condemned, for instance, if they punished their children for not achieving top scholastic results, or rewarded them for not shoplifting. Likewise, employers would be careful to use perverse incentive designs in the motivation of staff. In real-world economies, nonetheless, the incidence of counterproductive subsidies is wide-spread, as is the absence of positive intervention in the face of social and environmental failure.

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